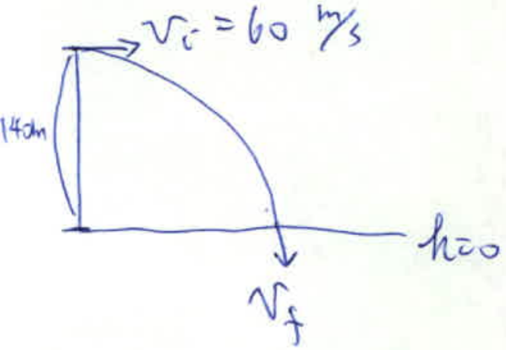
Physics 1A(a) Final Solutions for version A.

1~5	CAECE
6~10	DBECE
11~15	BACCE
15~20	DBADC
21~23	CED

① Use conservation of energy



$$K_i + U_i = K_f + U_f$$

$$\Rightarrow \frac{1}{2} m v_i^2 + mgh = \frac{1}{2} m v_f^2 + 0.$$

$$\cancel{\tfrac{1}{2}}\cancel{m} v_f^2 = \cancel{\tfrac{1}{2}}\cancel{m} v_i^2 + \overset{2}{\cancel{m}} g h$$

$$v_f^2 = v_i^2 + 2gh \qquad v_f = \sqrt{v_i^2 + 2gh}$$

$$v_f = \sqrt{60^2 + 2 \times 9.8 \times 140} \cong 80\,(m/s) \Longrightarrow \boxed{C}$$

②

$$\vec{\tau} = \frac{d\vec{L}}{dt} \qquad \int \vec{\tau} \cdot dt = \int d\vec{L} = \vec{L}_f - \vec{L}_i$$

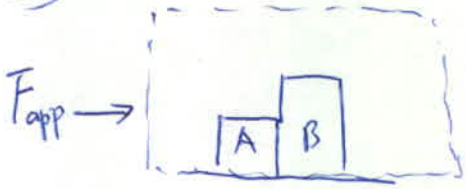
$\because$ The fan starts from rest $\vec{L}_i = 0$.

$\vec{\tau}$ is a constant $\int \vec{\tau} \cdot dt = \vec{\tau} \int dt = \vec{\tau} \cdot \Delta t$

$$\Rightarrow \quad \vec{\tau}\, \Delta t = \vec{L}_f \qquad \vec{L}_f = 0.110 \times 8 = 0.880 \left(kg\, m^2/s\right)$$

$$\Rightarrow \boxed{A}$$

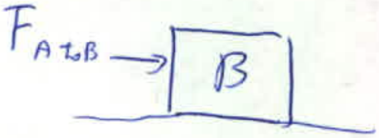
③ For the whole A+B system:



$$F_{app} = (m_A + m_B)\, a$$

$$a = \frac{F_{app}}{m_A + m_B} = \frac{36}{4+20} = \frac{9}{6} = \frac{3}{2}$$

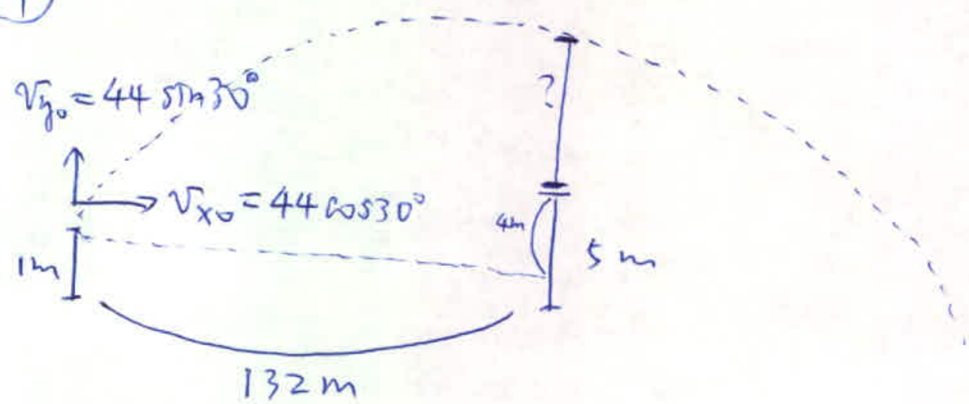
For B:



$$F_{A\,to\,B} = m_B\, a.$$

$$= 20 \cdot \frac{3}{2} = 30\,(N) \Rightarrow \boxed{E}$$

④



For the ball to travel 132 m along x direction

the time t needed is $\frac{\Delta x}{v_{x0}}$

$$t = \frac{132}{44\cos 30^\circ} = \frac{\cancel{132}^{\,3}}{\cancel{44}\cos 30^\circ} = 2\sqrt{3}\ (\text{sec})$$

In y direction $v_{y_0} = 44 \sin 30^\circ$ $a_y = -9.8$ $\Delta y = ?$

Use $\Delta y = v_{y_0} t + \frac{1}{2} a_y t^2$

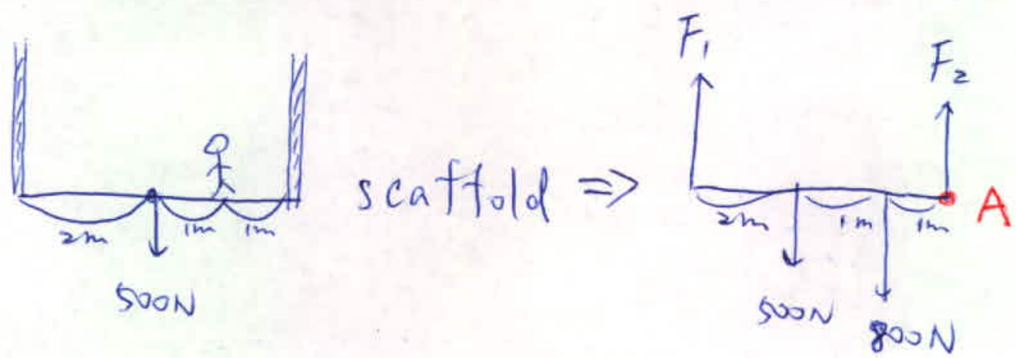
$\Delta y = (44 \sin 30^\circ)(2\sqrt{3}) - \frac{1}{2} 9.8 \, (2\sqrt{3})^2 \doteq 17.4 \ (m)$

The ball leaves the bat 1m above ground level, so the fence is $(5-1) = 4$ meters higher than the ball.

The ball clear the fence by

$$17.4 - 4 = 13.4 \ (m) \Rightarrow \boxed{C}$$

5.



$\Sigma F = 0$ and $\Sigma \tau = 0$

For $\Sigma F = 0$: $F_1 + F_2 = 500 + 800$

For $\Sigma \tau = 0$, choose A as pivot point

$-F_1 \times 4 + 500 \times 2 + 800 \times 1 = 0 \quad F_1 = \frac{1800}{4} = 450 \ (N)$

$F_2 = 1300 - 450 = 850 \ (N) \Rightarrow \boxed{E}$

(6) The kinematic equation $\Delta X = \underset{0}{\underset{\parallel}{V_{x0}}} + \frac{1}{2} a_x t^2$

Here, the initial velocity is zero.

For $t = 0.5$

$$0.75 = \frac{1}{2} a_x (0.5)^2 \quad a_x = \frac{\cancel{1.5}^{\,3}}{\cancel{0.5 \times 0.5}} = \frac{3}{0.5} = 6.$$

For $t = 2$

$$\Delta X = \frac{1}{2} \cdot 6 \cdot 2^2 = 12\ (m) \Rightarrow \boxed{D.}$$

(7)

$$V_{plane} = \frac{1770\ km}{4.4\ hrs} = 402 \left(km/hrs\right)$$

$$\left(V_{plane} + V_{wind}\right) = \frac{1770\ km}{4\ hrs} = 442\ (km/hrs)$$

$$V_{wind} = 442 - V_{plane} = 442 - 402 = 40 \left(km/hrs\right) \Rightarrow \boxed{B}$$

(8) After t seconds the cheetah catches its prey.

$$120\ km/hr = \frac{\cancel{120} \times 10^3}{\cancel{3600}_{30}}\ m/s = \frac{100}{3}\ m/s$$

$$90\ km/hr = \frac{\cancel{90} \times 10^3}{\cancel{3600}_{40}}\ m/s = \frac{100}{4}\ m/s$$

$v_{cheetah}\, t - v_{prey}\, t = 75 \text{ m}$

$\frac{100}{3} t - \frac{100}{4} t = 75$

$\frac{1}{12} t = \frac{75}{100} = \frac{3}{4} \qquad t = \frac{3}{4} \times 12 = 9 \ (sec) \Rightarrow \boxed{E}$

(9).

Buoyancy $F_B = V_{in} \rho_{water}\, g$. $\quad V_{in} = 0.6V$.

$V_{in} \rho_{water}\, g = mg$

$(0.6V)\rho_{water} = m \qquad \underbrace{\boxed{\frac{m}{V}}}_{\rho_{wood}} = 0.6\, \rho_{water}$

$= 0.6 \ 1000 \left(\frac{kg}{m^3}\right)$

$\boxed{C} \qquad = 600 \left(\frac{kg}{m^3}\right)$

(10).

The potential energy will be converted to kinetic energy, but during the process, part of the potential energy is dissipated by friction.

$m_B g h - \underbrace{F_f \cdot \Delta x}_{\substack{\text{work done} \\ \text{by friction,} \\ \text{dissipates energy.}}} = \frac{1}{2}(m_A + m_B)\, v_f^2$

$$v_f^2 = \frac{m_B g h - \overset{m_A g \mu}{\boxed{F_f}} \cdot \Delta x}{\frac{1}{2}(m_A + m_B)} = \frac{1.3 \times 9.8 \times 0.03 - 2.25 \times 9.8 \times 0.45 \times 0.03}{\frac{1}{2}(2.25 + 1.3)} = 0.0476$$

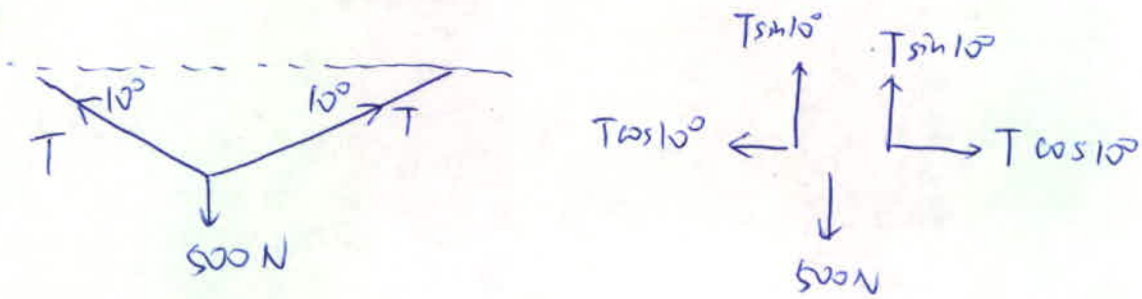
$$v_f = \sqrt{0.0476} \simeq 0.218 \ (m/s) \quad \Rightarrow \boxed{E}$$

(11) $\vec{A} = (5, 2) \quad \vec{B} = (1, 3) \quad \vec{C} = (-2, -2)$

$$\vec{A} + 2\vec{B} + \vec{C} = (5 + 2 - 2,\ 2 + 6 - 2) = (5, 6)$$

$$\sqrt{5^2 + 6^2} = 7.81 \ (m) \quad \Rightarrow \boxed{B}$$

(12)



$$500 = 2T \sin 10^\circ \quad T = \frac{250}{\sin 10^\circ} = 1440 \ (N) \quad \Rightarrow \boxed{A}$$

(13) $\Delta y = v_{y_0} t - \frac{1}{2} g t^2$

$t = 1 \quad \Delta y_1 = 17 \times 1 - \frac{1}{2} \times 9.8 \times 1^2 = 12.1 \ (m)$

$t = 2 \quad \Delta y_2 = 17 \times 2 - \frac{1}{2} \times 9.8 \times 2^2 = 14.4 \ (m)$

$\Delta y_2 - \Delta y_1 = 14.4 - 12.1 = 2.3 \ (m) \quad \rightarrow \boxed{C}$

(14.)

$$\Delta W = \Delta K = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 = \frac{1}{2} m (v_f^2 - v_i^2)$$

$$= \frac{1}{2} \times 5 (10^2 - 6^2) = \frac{5}{2} \times 64 = 5 \times 32 = 160 \text{ (J)} \Rightarrow \boxed{C}$$

(15.) Energy Conservation:

$$mgh \underbrace{- 20}_{\text{energy lost}} = \frac{1}{2} m v^2$$

$mg = 20$ (N) $h = 5 \sin 25^\circ = 2.1$ (m)

$\left(m = \frac{20}{9.8} (\text{kg}) \right)$

$20 \times 2.1 - 20 = \frac{1}{2} \left(\frac{20}{9.8} \right) v^2$ $v \doteq 4.7 \, (\text{m/s})$ $\boxed{E}$

(16.)

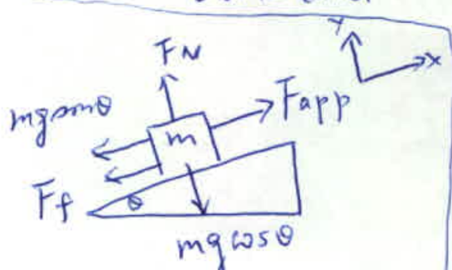
$$\Delta \vec{r} = \vec{r} - (0,0) = (12, 11)$$

$$W = \vec{F} \cdot \Delta \vec{r} = (12, -10) \cdot (12, 11) = 12^2 + (-10) \cdot (11)$$

$$= 144 - 110 = 34 \text{ (J)} \Rightarrow \boxed{D}$$

(17)

constant speed ⇒ no acceleration ⇒ no net force



F_f is the friction, $F_f = F_N \cdot \mu = mg \cos\theta \mu$

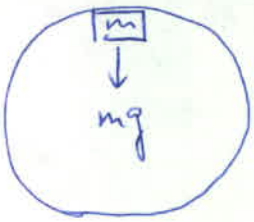
Along x direction: $\Sigma F_x = 0$

$$F_{app} = mg \sin\theta + mg \cos\theta \mu = mg(\sin\theta + \cos\theta \mu)$$

$F_{app} = 3.5 \times 9.8 \left(\sin 20^\circ + \cos 20^\circ \times 0.13 \right)$

$= 15.9 \ (N) \Rightarrow \boxed{B}$.

(18.)

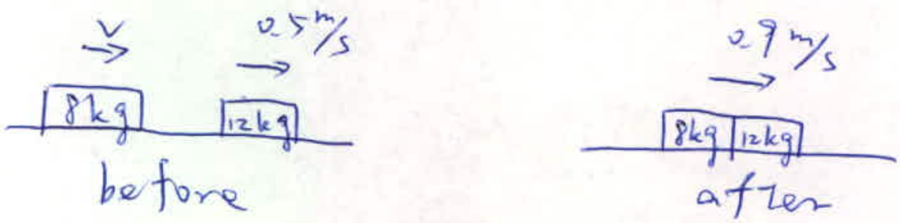


For the clown not to fall down, the gravity must serve as centripetal force.

$mg = F_c = m \dfrac{v^2}{r}$ $\qquad v = \sqrt{rg} = \sqrt{2.6 \times 9.8} = 5 \ (m/s)$

$\Rightarrow \boxed{A}$.

(19.)



Use momentum conservation to solve v.

$m_1 v_1 + m_2 v_2 = (m_1 + m_2) v_f$

$\Rightarrow \underline{8v + 12 \times 0.5 = (8+12) \times 0.9}$, $8v = 12$, $v = \frac{3}{2}$

loss of kinetic energy $= \underbrace{\frac{1}{2}(m_1 + m_2) v_f^2}_{\text{final}} - \underbrace{\left(\frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2\right)}_{\text{initial}}$

$= \frac{1}{2}(20) \times (0.9)^2 - \frac{1}{2} \times 8 \times \left(\frac{3}{2}\right)^2 - \frac{1}{2} \times 12 \times (0.5)^2$

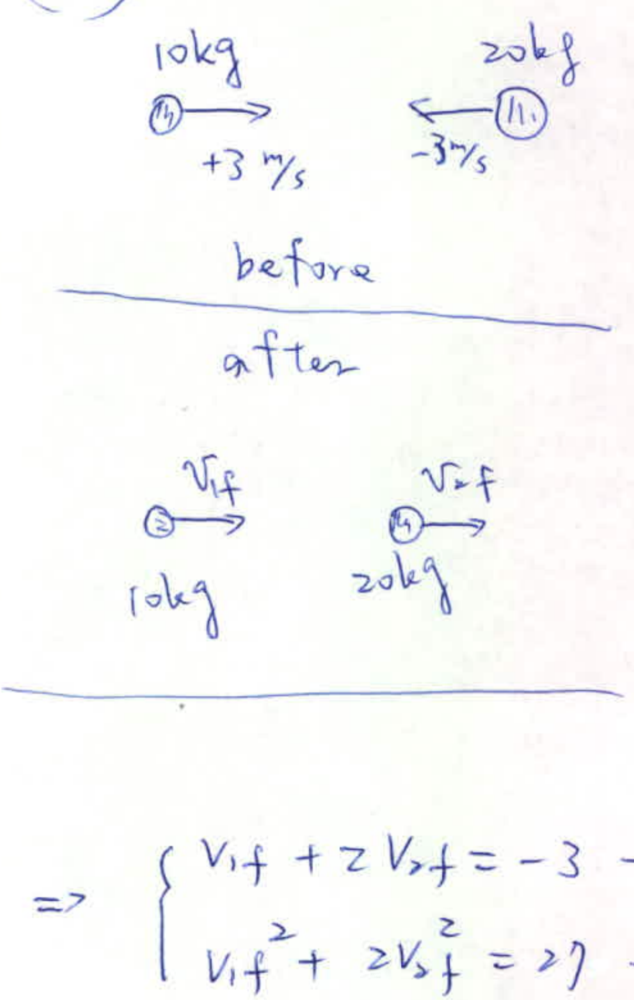
$= -2.4 \ (J) \Rightarrow \boxed{D.}$

(20) $\text{Impulse} = \Delta\vec{P} = \vec{P}_f - \vec{P}_i$

momentum change

$$12 \times 0.9 - 12 \times 0.5 = 12 \times 0.4 = 4.8\,(N.s.) \Rightarrow \boxed{C}$$

(21)



momentum conservation

$$10 \times 3 + 20(-3) = 10 \times V_{1f} + 20 \cdot V_{2f}$$

kinetic energy conservation:

$$\frac{1}{2}10 \cdot 3^2 + \frac{1}{2} \cdot 20 \cdot 3^2 = \frac{1}{2} \cdot 10 \cdot V_{1f}^2 + \frac{1}{2} \cdot 20 V_{2f}^2$$

$$\begin{cases} 10V_{1f} + 20V_{2f} = -30 \\ 10V_{1f}^2 + 20V_{2f}^2 = 270 \end{cases}$$

$$\Rightarrow \begin{cases} V_{1f} + 2V_{2f} = -3 \quad \text{--- } ① \\ V_{1f}^2 + 2V_{2f}^2 = 27 \quad \text{--- } ② \end{cases}$$

from ① $V_{1f} = -3 - 2V_{2f}$ insert into ②

$$(-3 - 2V_{2f})^2 + 2V_{2f}^2 = 27 \qquad 6V_{2f}^2 + 12V_{2f} - 18 = 0$$

$$V_{2f}^2 + 2V_{2f} - 3 = 0. \qquad (V_{2f} - 1)(V_{2f} + 3) = 0$$

$V_{2f} = +1 \left(\frac{m}{s}\right) \Rightarrow V_{1f} = -5 \left(\frac{m}{s}\right)$

$\hookrightarrow \boxed{C.}$

$\boxed{\text{for } V_{2f} = -3 \ \frac{m}{s} \quad V_{1f} = +3 \ \frac{m}{s}}$
This is the solution "before" collision

(22.) Potential energy => Kinetic energy => Spring
(at bottom) energy.

$$\underbrace{mgh = \frac{1}{2}mv^2 = \frac{1}{2}kx^2}_{\downarrow}$$

$2000 \times 9.8 \times 50 \sin 10^\circ = \frac{1}{2} k \, 1^2 \qquad k = 340 \times 10^3 \left(\frac{N}{m}\right)$

$= 340 \, k \left(\frac{N}{m}\right)$

=> (E.)

(23.)

$40 \frac{rev}{min} = \frac{40 \times 2\pi}{60} \left(\frac{1}{sec}\right) = \frac{4}{3}\pi \left(\frac{1}{sec}\right)$

$32 \frac{rev}{min} = \frac{\cancel{32}^{8} \times 2\pi}{\cancel{60}_{15}} = \frac{16}{15}\pi \left(\frac{1}{sec}\right)$

Angular momentum is conserved. => $I_i w_i = I_f w_f$

$31 \cdot \frac{4}{3}\pi = \left(31 + m \cdot (1.2)^2\right) \frac{16}{15}\pi$ $\qquad \boxed{D.}$

$31 = (31 + 1.44m)\frac{4}{5} \qquad 1.44\, m = \frac{31}{5} \cdot \frac{5}{4} \qquad m = 5.4kg$